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INT CL⁴ **F01D**

(54) **Turbine cooling arrangement**

(57) A stator mounted annular air outlet nozzle (1) directs cooling air from a swirl nozzle 3, to inserts 9, located between the blade bases and the rotor disc. The inserts 9, define deflection chambers 10 and supply cooling air to cooling ducts 10, 20, 21 in the rotor blades 22. The inserts may be of a one piece construction and glued sintered welded or soldered to the blade base. This arrangement minimises the seals necessary to conduct the cooling air and needs only low-mass rotor-side components.

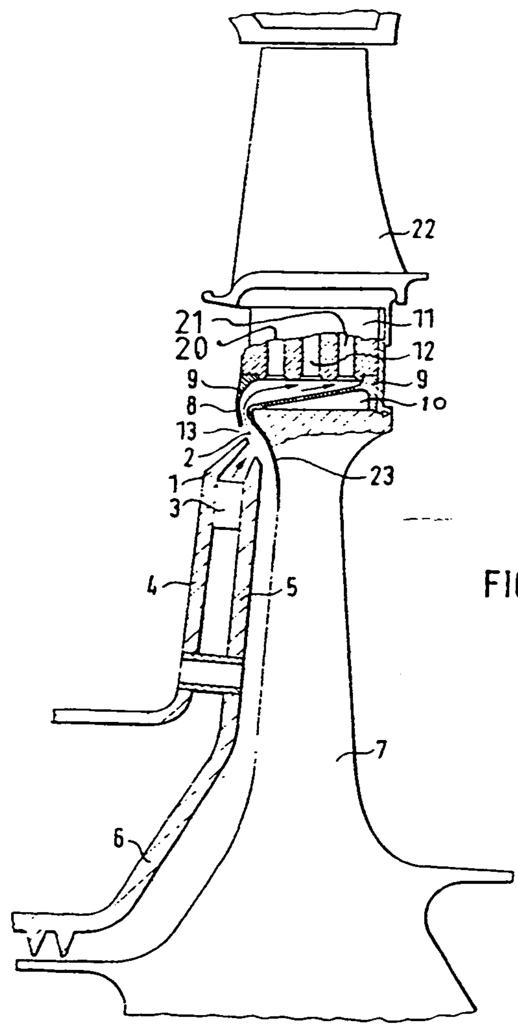

FIG. 1

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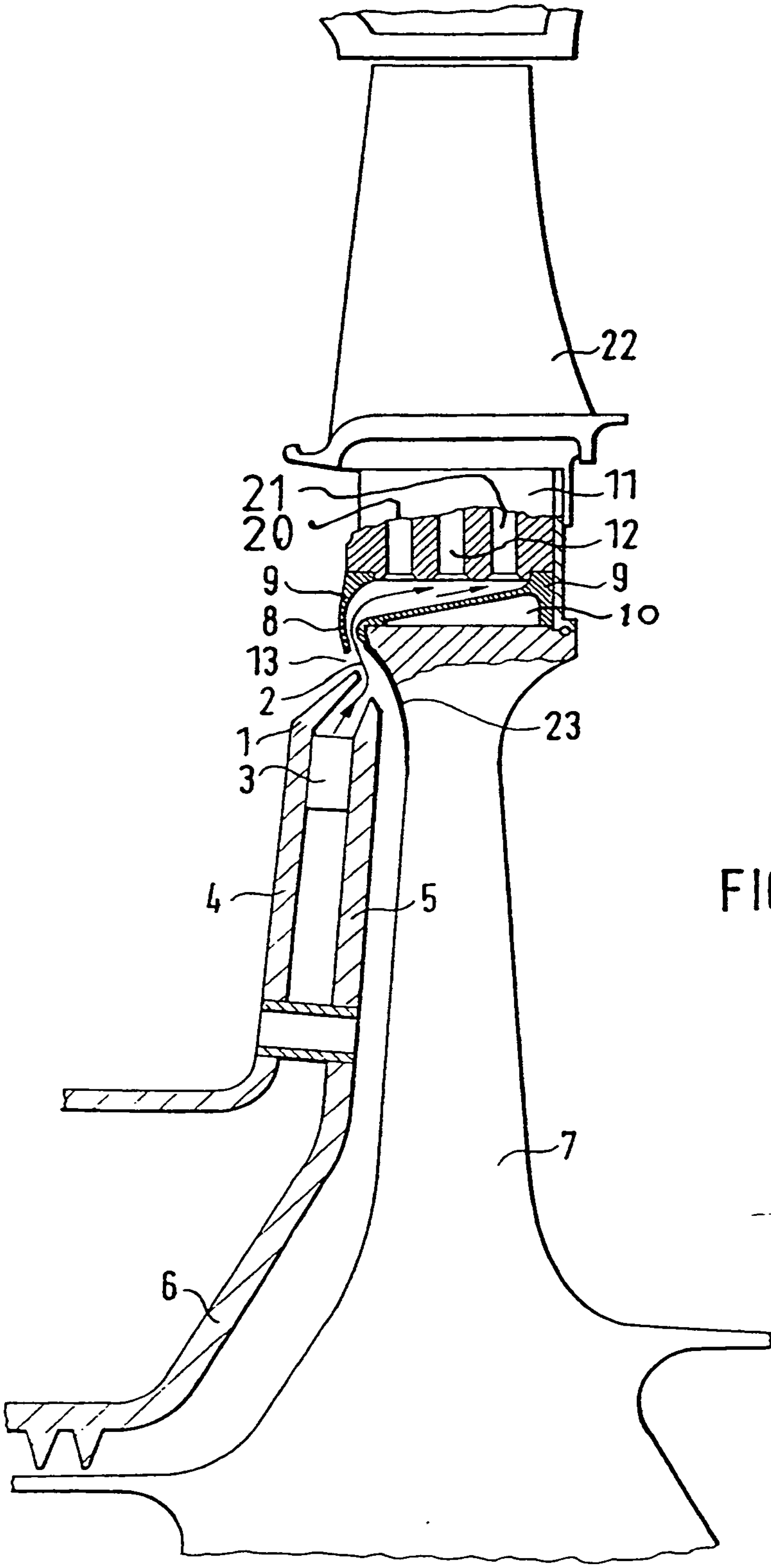


FIG. 1

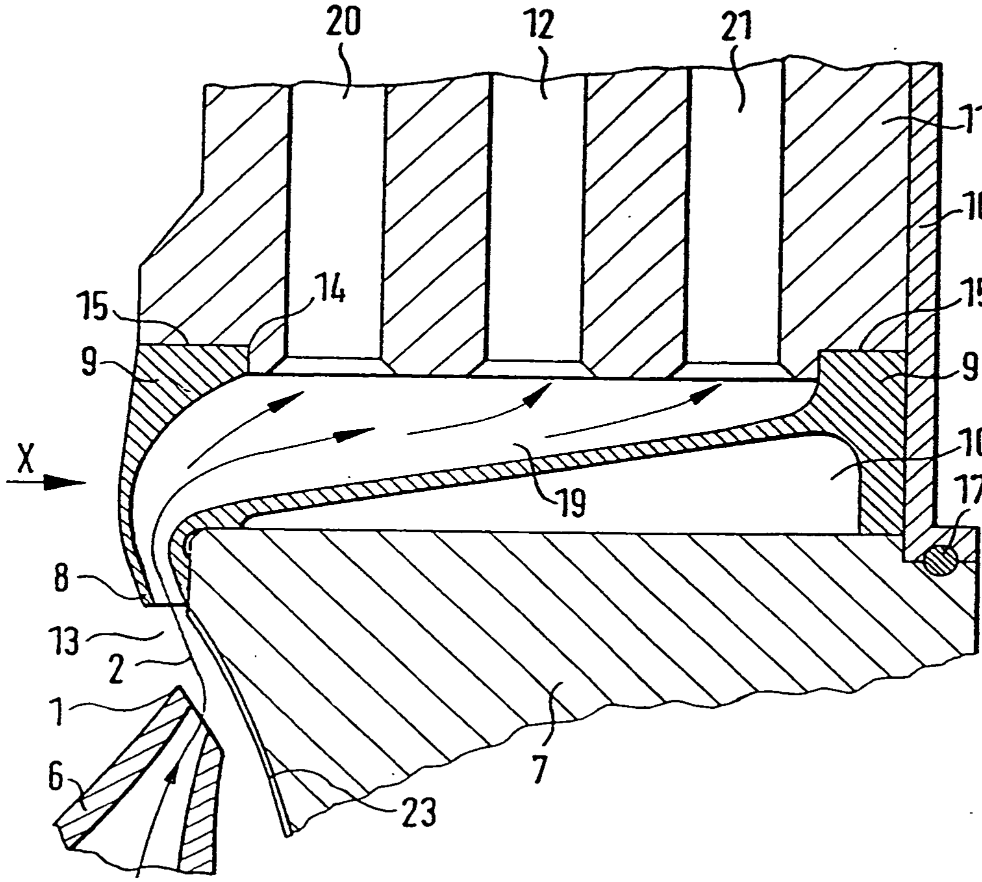
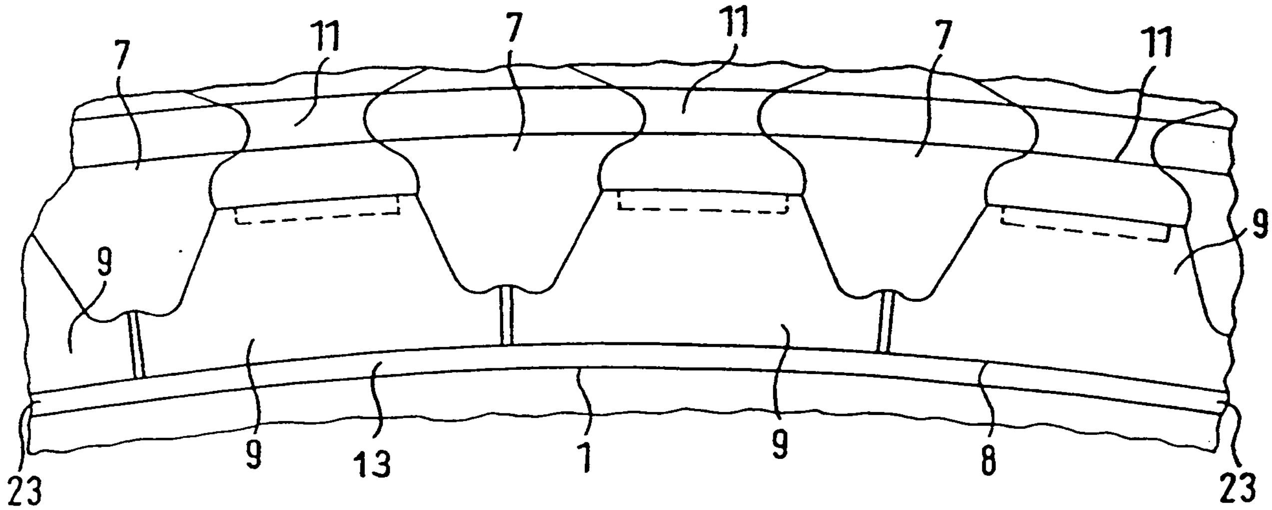


FIG. 2

FIG. 3



GAS TURBINE HAVING COOLING MEANS

This invention relates to a turbine comprising a stator and a rotor and means for supplying cooling air from the stator to rotor blades secured on the rotor.

A turbine of this type is known from DE-OS 18 14 430 which shows devices co-rotating for connection between the cooling chamber and coolant source. This means that there are large rotating masses in the form of rotating form-fitting spacers between the successive rotors. Further, the cooling air flow in the cooling chamber is deflected by means of cooling flow plates and sealing pieces so that several sealing surfaces are supported at the same time on different bodies. This does not guarantee a complete sealing of the cooling air flow because of the various body joints to be bridged.

In addition an apparatus is known from EP-00 43 300 for supplying cooling air for gas turbine rotor blades. Here a flange acting as a covering disc, sealed axially and in form-fitting manner with respect to the rotor wheel, joins the cooling chambers with the cooling air source arranged below or laterally of the blade bases of a rotor. When the cooling air flows in and through between the co-rotating flange or covering disc and the rotor disc the cooling gas is made turbulent and undergoes high friction losses because of, for example, Coriolis effects and the formation of Ekman layers. The pressure drop in the cooling air, which would be convertible into temperature reduction, is thus disadvantageously reduced. Hence the temperature reduction of the cooling air in covering disc systems is disadvantageously greatly restricted.

A direct low-contact supply of the cooling air from the stator to the rotating cooling chambers on the blade base, as is known from DE-OS 19 42 346, requires a gap seal with a large diameter which can be coupled

only at great expense to stator-side devices for adapting the gap to the different operational states of an engine.

According to the invention there is provided a turbine comprising a stator and a rotor and means for supplying cooling air from the stator to rotor blades secured on the rotor, wherein on the rotor the air supply means includes an insert fitted between each blade base and the rotor disc and forming a deflection chamber closed towards the low pressure side of the rotor, while on the high pressure side the or each insert projects radially inwardly towards the hub over the rotor disc edge so as to form an annular air inlet aperture of the deflection chamber, and on the stator the air supply means includes an annular air outlet nozzle directed generally radially outwardly towards the air inlet aperture.

Embodiments of the invention may provide a turbine where only relatively low rotating masses are necessary, a seal- and contact-free low-loss connection is produced between the stator-side cooling air source and the rotor-side cooling chamber, the air crossing a low-pressure region, and a large temperature drop in the cooling air may be brought about. Advantageously, stator-side expenditure is low, and at the same time the number of necessary sealing surfaces in the cooling chamber may be reduced and the need for devices for gap adaptation may be avoided.

With turbines in accordance with the invention the stator-side cooling air source is connected to a stator-side annular air outlet nozzle which produces a substantially radially outwardly directed cooling air stream which forms a homogenous annular cooling air screen. This cooling air screen hits an incident flow surface in the radially outer boundary region of the rotor disc and is deflected towards the annular

rotating air inlet aperture which may be formed from hub-side slots in annularly segmented inserts for the cooling chambers.

In order to adapt the flow from the air outlet nozzle, a static component, to the rotating annular segments of the air inlet aperture a circumferential component of velocity may be imparted to this cooling air stream by means of a further device mounted in front of the air outlet nozzle, such as, for example, a swirl nozzle.

Turbines constructed in accordance with the invention have the advantage that a completely contact-free connection is produced between the stator-side cooling air source and the rotor-side consumer and no devices of any kind have to be provided for gap adjustment. The rotating masses in the form of solid covering discs or spacers may be restricted to small-volume inserts in the cooling chambers which have a minimal additional weight if a suitable material is selected.

It is particularly advantageous to construct the insert as a one-piece unit.

In developments of the invention the insert is connected in form-fitting manner with a single annular press and seal fit towards the blade base. This seal fit of the insert guarantees the complete sealing of the cooling air stream in the cooling chamber since it is supported against a single component and does not have to pass over any body joints.

A preferred embodiment consists in forming the insert with the blade base by soldering, welding, gluing or sintering to form an integral component, thus advantageously achieving a simplified assembly, a smaller number of component pieces and the complete avoidance of sealing surfaces.

By shaping the insert aerodynamically in the

region of the cooling air flow the flow is deflected with low loss, regenerating the cooling air pressure, and is conveyed to the cooling ducts in the blades of the rotor. Hence a greater reduction in the temperature of the cooling gas is possible than with the solutions known from the prior art because of the low-loss conveying.

Lossy, for example turbulent, cooling flow components may moreover be separated during transfer from the air outlet nozzle to the air inlet aperture by an incident flow surface, in the boundary region of the rotor disc, i.e. the region nearest the blade base and generally adjacent to the inlet apertures, having a stream incidence at an angle of 20° to 50°, preferably 33°. This separated leakage flow has the same order of magnitude as the leakage flows of conventional gap seals.

The axial extent of the annular incident flow surface, which is inclined with respect to the turbine axis, is preferably greater than the operationally-determined axial movements between the stator-side air outlet nozzle and the rotor disc, so that in all operational states, when the cooling air stream has emerged from the air outlet nozzle, it first of all hits the incident flow surface and then is deflected towards the air inlet aperture. This has the advantage that in all operational conditions the air inlet aperture has an optimal air flow towards it.

In order to optimise the air flow separated before the air inlet nozzle, the air inlet aperture is preferably of narrower construction than the air outlet nozzle. This arrangement has the advantage that a low-loss pressure accumulation in the cooling chamber insert is achieved.

It is particularly simple to design the insert as a sintered metal body or a cast metal body. Preferably

blade materials based on nickel or cobalt are used as basic materials for the insert so that they display a heat expansion behaviour which matches the blade bases.

A further embodiment of the invention consists in making the inserts preferably from oxide or sintered ceramic materials since these materials keep the rotating masses small by virtue of their low density.

For a better understanding of the invention, embodiments of it will now be described with reference to the accompanying drawings, in which:

Fig. 1 shows schematically in cross section an apparatus in accordance with the invention for supplying cooling gas for gas turbine rotor blades;

Fig. 2 is a detail of Fig. 1 showing an insert in a cooling chamber under a blade base; and

Fig. 3 shows a front partial view corresponding to Fig. 1.

Fig. 1 shows schematically an apparatus in accordance with the invention having a stator-side annular air outlet nozzle 1 which produces a homogenous contact-free cooling air stream 2 directed generally radially outwardly in the direction of the arrow. A circumferential component is imparted to this cooling air stream 2 by means of a swirl nozzle 3 which is arranged between two disc-like covering plates 4 and 5. The air outlet nozzle 1 directs the cooling air stream 2 into an annular gap 13 between the stator 6 and the rotor 7, where it encounters an incident flow surface 23 in the boundary region of the rotor disc ~~7~~. The incident flow surface 23, which is inclined with respect to the normal plane of the turbine axis, deflects the cooling air flow to an air inlet aperture 8 of an insert 9 of a cooling air chamber 10 under the blade base 11 of a blade 22. The insert 9 deflects the cooling air stream 2 after it has entered the air inlet aperture 8 (see arrows) and conveys it to the cooling

air ducts 12, 20 and 21 in the blade base 11.

Fig. 2 shows, from the example according to Fig. 1, a cross-section of the insert 9 in the cooling chamber 10. The insert 9 deflects the generally radially directed cooling air flow 2, after it has entered the air inlet aperture 8 of the insert 9 across the annular gap 13 between the stator 6 and the rotor disc 7 after deflection by the incident flow surface 23, into the cooling air ducts 12, 20 and 21 of the blade base 11. The cooling air flows through the deflection area 19, shaped for easy flow. The insert 9 is connected in form-fitting manner to the blade base 11 by a centering projection 14 annularly surrounding the blade base 11 and is sealed in gas-tight manner by the sealing seat 15. The blades and the insert are secured against axial movements by the securing disc 16 and the annular securing insert 17.

Fig. 3 shows a section of a front view of the embodiment according to Fig. 1 showing three blade positions of a rotor disc 7. The associated inserts 9 project over the edge of the rotor disc 7 and form an air inlet aperture 8 which lies substantially radially outwardly opposite the stator-side air outlet nozzle 1. In the annular gap 13 between the air inlet aperture 8 and the air outlet nozzle 1 lies the incident flow surface 23 in the boundary region of the rotor disc 7. Although the air outlet nozzle 1 is shown as continuous in Fig. 3 it could also consist of a series of segments.

CLAIMS:

1. A turbine comprising a stator and a rotor and means for supplying cooling air from the stator to rotor blades secured on the rotor, wherein on the rotor the air supply means includes an insert fitted between each blade base and the rotor disc and forming a deflection chamber closed towards the low pressure side of the rotor, while on the high pressure side the or each insert projects radially inwardly towards the hub over the rotor disc edge so as to form an annular air inlet aperture of the deflection chamber, and on the stator the air supply means includes an annular air outlet nozzle directed generally radially outwardly towards the air inlet aperture.

2. A turbine according to claim 1, wherein the insert is in one piece.

3. A turbine according to claim 1 or 2, wherein the insert is a sintered metal or cast metal body comprising a nickel or cobalt alloy.

4. A turbine according to claim 1 to 2, wherein the insert is a sintered body of ceramics.

5. A turbine according to any preceding claim, wherein the insert has a centering projection for the blade base with a single sealing seat between it and the blade base.

6. A turbine according to any preceding claim, wherein the blade base and the insert form an integral component.

7. A turbine according to any preceding claim, wherein the cooling air stream from the air outlet nozzle is directed at an angle of 20° to 50°, preferably 33°, onto an annular incident flow surface in the region of the rotor disc adjacent to the inlet aperture, for separating turbulent boundary layers of the cooling air stream.

8. A turbine according to claim 7, wherein the

incident flow surface is inclined with respect to a radial plane and its axial extent is greater than the axial movements which can occur between the stator-side air outlet nozzle and the rotor disc during operation of the turbine.

9. A turbine according to any preceding claim, wherein the annular air inlet aperture has a narrower slot than the air outlet nozzle.

10. A turbine according to any preceding claim, wherein a device for producing a flow component in the circumferential direction is connected in series with the annular air outlet nozzle.

11. A turbine according to any preceding claim, wherein each rotor blade is secured on the rotor in form- and force-fitting manner so as to form, with the rotor, a cooling chamber including the insert and the deflection chamber, the cooling chamber being connected to cooling ducts leading through the blades.

12. A turbine substantially as described herein with reference to the accompanying drawings.

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